

Quality cost in bus operations based on activity-based costing

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The study of service quality and its implication for transport contracts has several approaches in research and practical applications, where the main emphasis is the consideration of quality from the user's point of view, thus obtaining a customer satisfaction index as a measurement of the overall quality with no further implications for service providers. The main aim of this paper is to estimate the real economic impact of improving quality attributes for a bus operator. An application of the activity-based costing methodology is developed for a bus contract in Madrid, using quality data from surveys together with economic and performance information, and focusing on headway as a quality variable. Results show the consistency and practicality of this methodology, overcoming simplifications from traditional procedures. This method is a powerful tool in quality-based contracting as well as for effective investment in transport quality under poverty funding constraints.

1. Introduction

The study of quality has seen major progress in linking the fields of research and practice with the Quattro project 'Quality approach in tendering urban transport public operations' (European Commission, 1998), the objectives of which were the definition and introduction of quality indicators into tendering and contracting public transport services. The Quattro project was the basis for the European Standard EN 13816:2002 (CEN, 2002) 'Quality of service in passenger transport services'.

In parallel, in the USA, the emphasis was the measurement of service quality through customer satisfaction as evidenced by the *Handbook for Measuring Customer Satisfaction and Service Quality* (TRB, 1999) or the *Transit Capacity and Quality of Service Manual* (TRB, 2013).

Besides these two systemic and practical approaches, research on service quality in recent years has focused on other aspects. Methods for measuring service quality include statistical analysis of user surveys, such as factor analysis, correlations and clustering. Examples are given by Akan (1995), Hill (2000, 2003), Felleeson and Friman (2008) and Eboli and Mazzulla (2011). Other methods consider overall service quality as a combination of several attributes. These include

regression models, structural equation models (SEM), logit models, and so on. Some examples can be found in the papers by Vilares and Coelho (2003) and Dell'Olio *et al.* (2010). Rojo *et al.* (2011) developed models for some specific quality issues such as gender perception. More recently, De Oña *et al.* (2012) have used the decision trees (Cart) technique.

Hensher and Prioni (2002) considered a new approach to quality in public transport contracts trying to measure service quality indicators (SQI), with several techniques (including stated preference surveys), making quality in contracts dependable on the user's perspective. This approach distinguishes between the considered importance of several attributes for users (expected quality), and the scoring on these attributes for a particular service (perceived quality). Some additional evidence of the importance given to quality in tendering can be found in the paper by López-Lambas and García-Pastor (2008).

Nevertheless, none of these methodologies considers the pure economic implications of reaching a certain quality level, or the improvement of quality components, regardless of the user's perception. This is particularly important for operators, who are normally in an intermediate position between authorities and final users.

Once quality attributes are identified, there is still a difficulty in measuring the economic impact of improvements. One of the most interesting methods, used for costing analysis based on processes and activities, is the activity-based costing (ABC) method. The main references for the ABC methodology, considered as the origin of this approach, are the studies developed by Cooper and Kaplan in the late 1980s in the *Harvard Business Review*, which established the initial basis for its application in USA. These academic developments explained and formally structured different partial applications for the 1970s and the 1980s, with subsequent adaptations such as time-driven ABC (TDABC), made by Kaplan and Anderson (2007).

Turney (2010) analysed the evolution of the use of the ABC methodology since the 1980s to present. The curve in Figure 1 shows the life cycle of ABC methodology considering its application and the complexity and maturity of the method. An initial expansion is followed by a fall, owing to criticism of the model, and through subsequent growth the method is improved and new utilities are incorporated.

This paper presents a new approach in the application of the ABC methodology to quality in public transport, through the development of a real case study of a contract for bus suburban services in the Madrid metropolitan area. Passenger's surveys were conducted to ascertain the main quality attributes and the main performance indicators of this contract were collected.

An application of the ABC method to one of the identified quality attributes (headway) is developed in order to show the practical implications.

2. Application of ABC methodology in transport and in service quality analysis

Starting with the initial theoretical framework developed by Cooper and Kaplan at the end of the 1980s (see for example Cooper and Kaplan (1991, 1992)), the application of the ABC methodology spread immediately to the manufacturing companies, where the identification of processes, activities and cost centres is clearer and more direct than in service companies. For example, Heredia (2010) developed an application of the ABC method to the clothing industry.

The possibilities and advantages of the ABC method in manufacturing companies have helped to spread the use of the method in service companies, where the definition of activities, the associated unit variable cost and the distribution of indirect costs are not very apparent.

Chea (2011) highlights some differences in the approach, since service companies presently use more staff than manufacturing companies. Besides, generally more staff are engaged in customer-oriented activities (marketing, sales, customer service and so on), which are treated as indirect costs (overheads). The ABC

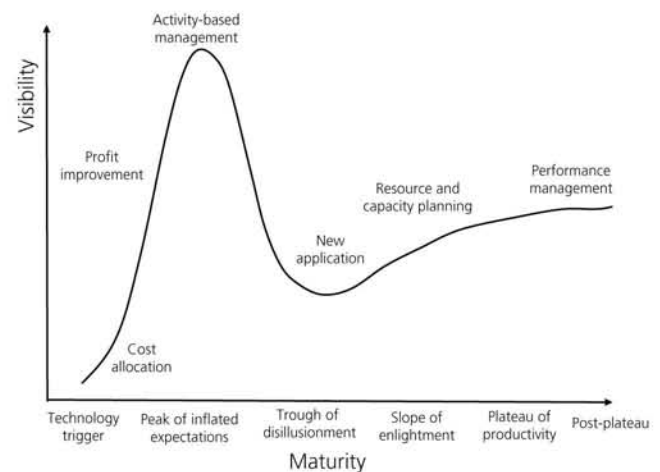


Figure 1. ABC hype cycle. Source: Turney (2010)

methodology allocates overheads more accurately and rationally than traditional methods.

There are some applications of the ABC approach to the cost of quality. Examples of the application of the method can be found, for example in the paper by Tsai (1998), who specifically evaluated and proposed an integration of quality costs and the ABC method. Total quality management and implementation of the ABC method to analyse activities and costs have also been studied in several papers (Novičević and Antić, 1999). Ruhupatty and Maguad (2011) present another interesting example, using the ABC methodology to measure the cost of quality in higher education. These papers conclude that the costs of quality are usually considered as indirect costs and redistributed using several criteria, which are not always very suitable.

There are not many references in the existing scientific literature on the application of the ABC method in transport companies and more specifically to public transport. Some examples are the case of a logistic transport company, see Baykasoğlu and Kaplanoğlu (2008) or Tsai and Kuo (2004), in which the ABC method is applied to the aviation industry. Popesko and Novák (2011) applied the ABC methodology to a mass urban transport company in Zlin (Czech Republic), in one of the few existing references.

The application of ABC to urban transport has special characteristics since services are more difficult to define and the determination of activities and cost parameters is not direct. Data collection is more complicated in service companies than in the manufacturing sector.

3. Brief description of the activity-based costing methodology

The ABC method was one of the most innovative practical approaches in the analysis of business costing performance,

emerging as an alternative to classical accounting, which bases the analysis on departmental cost items, not taking into account the impact of activity efficiency on the final product or service.

The shortcomings of traditional cost based on general accounting procedures include over or under costing, neglecting of underlying activities, difficulties to assign indirect costs and so on.

The core of the ABC method is the concept of activity linked to processes and operations to obtain a product or service. The degree of complexity of the company, its degree of diversification, the range and type of products and so on, determine the multiplicity and complexity of activities and subsequently the methodology tends to become more difficult to implement.

3.1 Basic concepts

The main concepts to consider when applying the ABC methodology are outlined below.

- **Activities.** An activity is a task developed in a company, normally with a certain objective and usually as part of more complex process. There are several types of activities within a company. One of the most important classifications for the ABC method is the differentiation between main activities and supporting activities, the former being the main value-adding factor in company processes, whereas the latter are not central but still necessary, particularly when overhead and marketing tasks account for more than 50% of the total costs.
- **Cost object.** This is the other major concept emerging from the ABC methodology. It simply represents the basic unit to be analysed. Cost objects are usually types of products, branch offices, specific markets, and so on, and although they are broken down in segments and groups deriving from classical accounting, sometimes it is interesting to analyse objects that are not so straightforward.
- **Cost generators.** The concept of cost generators is paramount to the ABC method and represents the consumer unit from which overall costs can be distributed to the activities. In an approximate way, it is the same concept as 'work unit' in construction. The number of cost generators depends on several factors reflecting the precision required in the analysis. The definition of cost generators must consider the measurement of temporal units against the number of tasks (number of inspections, number of shipments, etc.), the degree of correlation and so on.

3.2 Process of application of the ABC method

The application of the ABC method has some variations in the existing literature, but generally, four steps are needed to cover the whole approach

- definition of cost objects, main and supporting activities, and resources and cost generators or drivers

- development of a diagram representing the flow of activities, resources and the relationship between them
- collection of relevant data regarding costs and relations between cost generator and resources and activities; calculation of activity costs
- calculation and interpretation of the information based on activities.

The phase of cost allocation to the cost objects is fundamental to the application of the ABC methodology, and the one that determines the outcome resulting from all calculations and definitions. This process is usually quite complex, requiring in-depth interviews with company staff, and subsequent interpretations of the results. This is crucial, as there is not a single approach to ABC method application for all companies, and therefore there is a need to adapt it to each particular environment.

A summary of the ABC method is given in Figure 2. Cost objects (products, customers, branches and so on) are fed by activities, and activities create the need for resources. The ABC technique uses a two-stage procedure to assign resource costs to cost objects. In the first phase by means of selected cost generators, general costs are assigned to various activities. Thus, the total cost associated with an activity is made up by the contributions from different resources.

In the second stage, the different activity costs are traced to cost objects by using the different kinds of activity drivers, these usually being similar to the cost generators mentioned above. If cost objects are products, then the total cost of a specific product can be calculated by adding the costs of the various activities assigned to that product.

The potential of ABC methodology in determining costs allocated to specific objects lies in the treatment of overheads and indirect or non-traceable costs. Although direct costs in most cases can be assigned to the cost objects according to the intensity of use (for instance, hours in the case of direct staff), overheads need appropriate cost generators and drivers to be assigned. That is the reason why many authors perform an initial assignment of indirect costs to activities to proceed with a subsequent assignment on primary activities.

4. Case study of transport services in a metropolitan corridor in Madrid

In order to analyse quality attributes and their impact on operator costs, the ABC methodology has been applied to a group of urban/metropolitan services in one of the most important metropolitan corridors in the region of Madrid, the corridor around M-607. Heading towards the north of Madrid, starting from the interchange at Plaza de Castilla and connecting Cantoblanco University, El Goloso and Tres Cantos, the corridor is 20 km long, as shown in Figure 3.

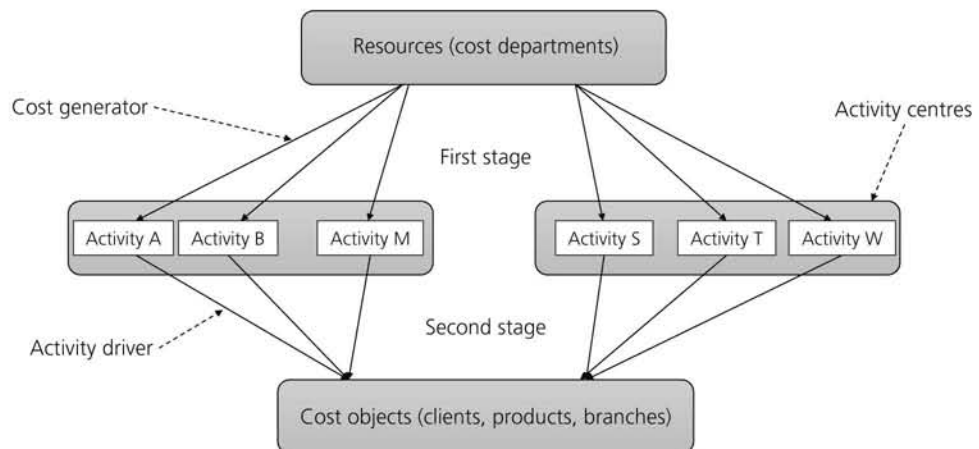


Figure 2. Cost assignment view of ABC. Source: Tsai and Kuo (2004)

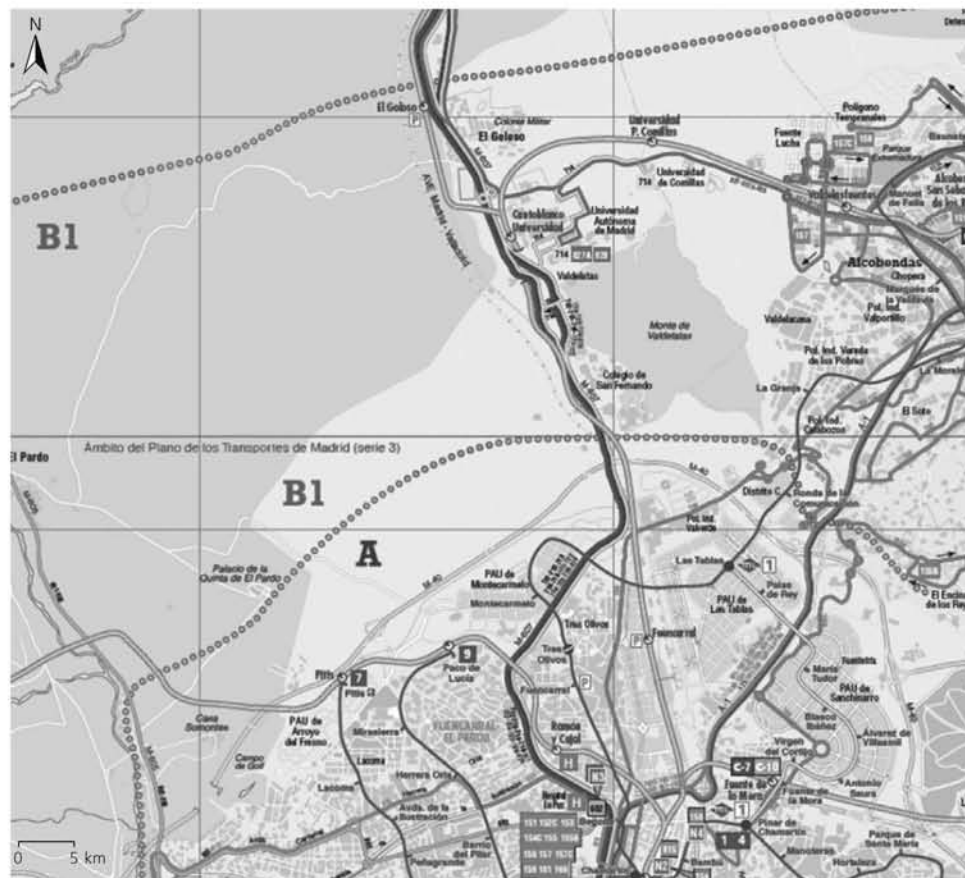


Figure 3. Metropolitan corridor M-607. Source: Consorcio Regional de Transportes de Madrid

Suburban bus services in Spain are usually tendered in route bundles according to factors such as line proximity, feasibility of lines, avoiding overlapping and so on. Contracts are normally subject to European Regulation 1370:2007 (EC, 2007) on public passenger transport services by rail and by road, which envisages the concept of public service obligations (PSO) and other national requirements.

In the case study, the bundle is a combination of pure metropolitan lines connecting the city of Madrid at one of the mayor interchanges (Plaza de Castilla), with the municipality of Tres Cantos, a city located 20 km north of Madrid with a population of 50 000 inhabitants. There are four additional urban services within the municipality of Tres Cantos, which are also included in the contract. Owing to data availability, for the purposes of this paper all lines are considered together.

All urban lines connect the suburban railway station of Tres Cantos with different areas of the municipality. The main characteristics of these lines are shown in Table 1.

Suburban lines connect Madrid with the municipality of Tres Cantos (lines 712, 713 and 716), and with the University of Cantoblanco (line 714). All these lines have their terminal in Madrid at the Plaza de Castilla interchange and have final terminals in different zones in Tres Cantos. The main characteristics of these lines are shown in Table 2.

Qualitative research focused on two types of surveys: expected and perceived quality. The main objective of these surveys was to identify the most important quality attributes to which the ABC method could be applied. Owing to technical reasons, surveys were made in suburban lines only, but the suburban characteristics of these lines mean that their quality expectations and perceptions are similar in all services.

Perceived quality surveys were made through face-to-face interviews, whereas expected quality surveys were carried out with the help of ranking cards. Both surveys were made at the interchange and on board.

Quality variables in surveys were selected from existing literature, particularly from a specific study made by the Madrid

Line	Length: km	Travel time (one direction): min	Headway peak hour (PH): min	Passengers per annum
L1	8.3	40	15	238 042
L2	6.6	30	15	190 979
L3	6.8	30	35	103 863
L4	5.8	25	40	48 222

Table 1. Urban lines of Tres Cantos

Public Transport Authority (CRTM, 2007). The choice of variables is not straightforward, and it usually derives from exhaustive lists of variables (for instance the one included in EN 13816 (CEN, 2002)), but some variables are chosen through user surveys. Authors such as dell'Olio *et al.* (2010) indicate that the identification of variables and their significance should be made separately from perception surveys. Focus group methodologies are suitable for this objective. Variables typically include cleaning, punctuality, safety, information, headway and so on. In the case of transport nodes or interchanges, Dell'Asin *et al.* (2014) identified up to 16 key quality factors associated with user's perception.

After classification and calculation in the perception survey, distribution and weights for each variable were obtained from the expected quality survey. The three most important variables accounting for 50% of the overall quality were punctuality, headway and safety. These results are consistent with the research performed by the above-mentioned CRTM research.

Accordingly, the main objective is to find out how much the operator's real cost of improvements in these quality variables (the provider side in the quality loop) would be. The economic impact can be less efficient if variables are costly but not important for the user, whereas in other cases a small economic effort can have a wider and more effective impact.

The variable 'headway' shows a high potential for improvement, since it is one of the most important according to the users, whereas overall perception is very low compared to other attributes. This variable is also straightforward to modify by operators and authorities (with adequate resources), and has a substantial economic impact compared to other quality variables. In the following section, the ABC method is used to investigate the operator's economic cost of improving headway as a quality variable.

5. Application of ABC methodology to analyse the cost of headway as a quality variable

The application of ABC methodology to the analysis of headway as a quality attribute shows some particularities.

- Headway is a composite variable, a function of travel time, commercial speed and, therefore, commercial mileage. Thus, the improvement of headway affects different items.
- Available data on a line or set of lines are influenced by certain factors related to the type of service provided (urban, metropolitan and so on), the size of the company and the contract and the characteristics of the service.

This application of the ABC method follows the general steps of the approach as shown in Figure 4. Once the operator cost

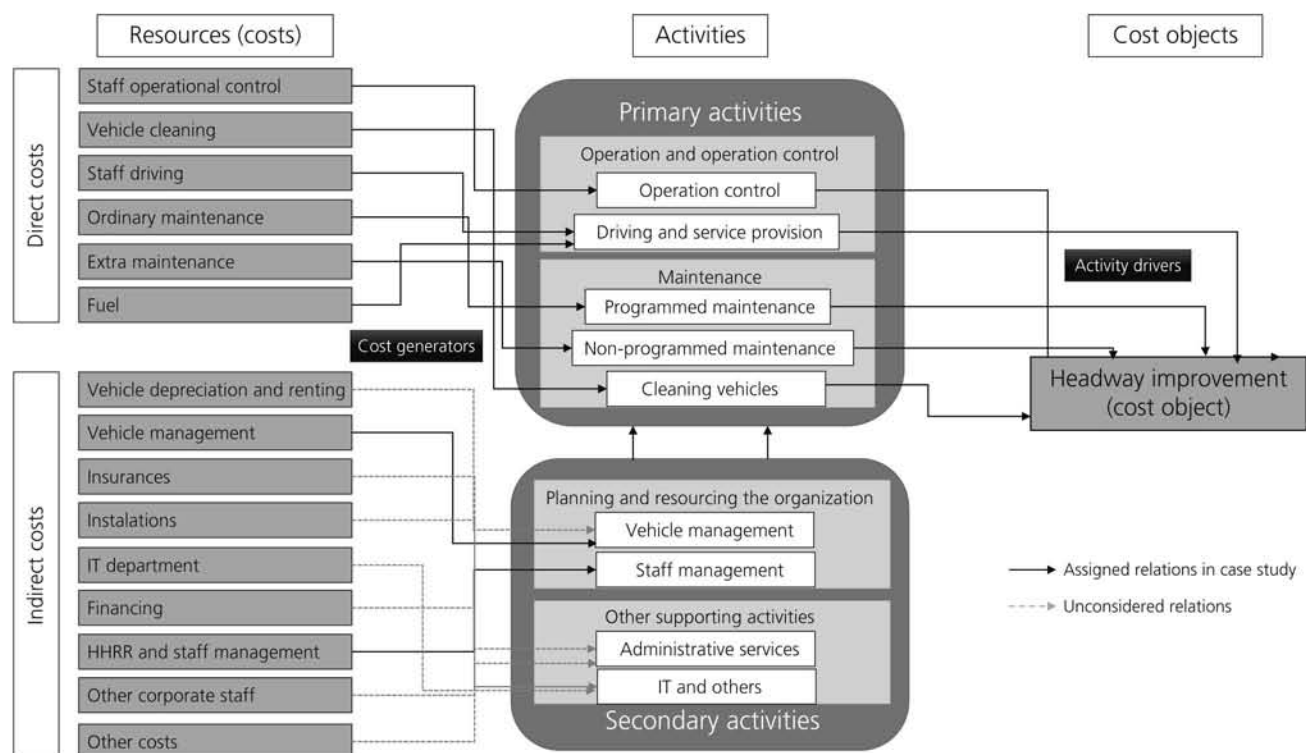


Figure 4. General diagram of application of the ABC methodology to the study case

structure was analysed, great effort was devoted to design this diagram, in which relations and activities were defined starting from the interviews with staff, as explained later. Secondary activities are merged in the first stage into primary activities according to the interviews with key staff, which also helped to define the assignment consideration of costs to activities.

5.1 General cost information and performance variables

The contract of Tres Cantos has a mixture of four urban lines and four metropolitan lines. The organization of the operator, which manages a large number of other contracts, makes this bundle a single unit for cost reporting. For the purposes of this research, the operator provided all cost and performance data, subject to confidentiality for disaggregate information.

Costs correspond to those of 2013. A separate line costing was not available from the operator, so the whole contract is considered as a unit. Table 3 displays the cost structure, dividing it between direct costs and indirect or secondary costs, according to the company accounting system, which closely resembles the activity structure.

This contract is controlled by the Public Transport Authority in Madrid (Consortio Regional de Transportes de Madrid), which establishes the general rules to operate the contract,

Line	Length: km	Travel time (one direction): min	Headway peak hour (PH): min	Passengers per annum
712	22.3	45	15	1 050 901
713	21.3	45	15	879 525
714	11.5/13	35	12	687 099
716	22.8	35	20	651 455

Table 2. Main characteristics of suburban lines of Tres Cantos

meaning for instance that the operator cannot manage stops and shelter provision or information. Hence no associated costs are considered.

Some general characteristics of this cost structure should be noted: indirect costs, according to the company classification account for 46.3% of total costs, which is similar to other service companies. Most of the items can be linked directly to an activity (for instance vehicle driving costs are a direct result of the activity/operation, and they are fully assigned to it). There are also some indirect costs, which have a more difficult consideration. This is precisely one of the strengths of the ABC method – that is, the way it assigns overhead to

activities – and it needs to be checked with the company managers in order to link the costs with activities. This will be reviewed in the next section.

On the other hand, some key performance indicators (KPIs) of this operation have also been collected to create cost generators. Table 4 shows a summary of the main indicators.

The first ratio obtained from the two sets of data is the global cost/km, which is a traditional costing tool commonly used by operators and administrations. The reason for using this ratio

Cost/resource	Cost in 2013: €	%
Control of operation	102 285	0.9
Vehicle cleaning	131 339	1.2
Vehicle driving	3 367 772	31.1
Ordinary maintenance	526 185	4.9
Non-scheduled maintenance	156 432	1.4
Fuel	1 535 010	14.2
Total direct costs	5 819 024	53.7
Vehicle depreciation and renting	1 328 406	12.3
Vehicle management	1 379 269	12.7
Insurances	247 767	2.3
Installations	316 216	2.9
IT	36 698	0.3
Financing	305 624	2.8
Human resources (HR) and staff management	226 107	2.1
Other costs	1 167 192	10.8
Total indirect costs	5 007 278	46.3
Total costs	10 826 302	100.0

Table 3. Annual cost structure of Tres Cantos operation. Source: Operator

Indicator	Value
Journeys	178 240
Mileage: km	3 282 283
Passengers	3 903 308
Buses	39
Drivers	74.87
Other staff	7.63
Commercial speed: km/h	23.87
Workshop hours	8748
Operation hours	137 169
Average frequency: min	22.6

Table 4. Tres Cantos annual operational indicators in 2013. Source: Operator

is that most direct costs are related to mileage. In this case this ratio is €3298/km. The application of the ABC method will reveal the differences with direct calculations based on this indicator, usual in transport companies.

5.2 Interviews with key staff

A key task in every ABC application lies in the most accurate definition of activities and allocation of resources, as well as the identification of the cost drivers. This is a relatively complex task as there is a tendency to confuse costs and activities and their influence on the cost objects. The objective is to create a map of processes and activities of the company, based on in-depth interviews with members of the staff. Some activities match the future cost objects and simplify the allocation of the activity costs to cost objects. This is quite important since the nature of the cost object can determine activity grouping and cost driver identification.

In the study, three meetings with key staff of the company (finance, innovation and operation) were carried out over several months in 2014. The general objectives of the application of the ABC method were explained, highlighting the consideration of headway as a cost object. During these meetings a review of organisation, management and cost structure was made, which led to some considerations, the most important being that, inasmuch as this contract constitutes a cost centre, overheads from the cost structure are already assigned at a higher level.

This is why in the definition of activities and the allocation of costs to them, some overheads are not considered, as indicated in Figure 4. The following sections present the main results from the interviews and research.

5.3 Activity definition

Taking into account that the cost object is ‘headway’, the discussions held during the interviews addressed the identification of activities related to this variable. Furthermore, a clear distinction was made between ‘headway’ and ‘headway improvement’, the latter being more appropriate for the analysis of quality, since headway itself is not a quality attribute, but a definition of the service. It is only when marginal improvements take place that quality improves.

The activity chain for the contract, according to these remarks is shown in Figure 5. It also includes a breakdown into more detailed subactivities that closely resemble the cost structure.

The most important analysis took effect when indirect activities were considered. As stated before, most of the overheads come from an initial assignment, and they do not influence (in other words they are not assigned to) any activity. The cost items left out in the analysis were vehicle depreciation and renting, insurances, installations, IT, financing, and most



Figure 5. Activity chain and activity breakdown

of the remaining costs such as canon, legal consultancy, and so on.

The rationale behind leaving these costs out of the ABC model was their consideration as structure costs, without any influence on activities, particularly for the analysis of headway improvements.

The discussion maintained during the interviews was very fruitful in terms of the company approach to quality variables. Improvements of quality within a very demanding environment influence the associated costs. Starting from very low levels of quality would have more impact on costs, as the required levels should be higher in percentage. This also goes deeply into the idea of quality 'bundling', in the sense that improvements (and most likely perceptions) are provided in packages or levels.

5.4 Cost generator selection

The other key item analysed in the interviews was the set of cost generators to be used for assigning cost to activities and activity influence on the cost object (headway). In general terms, headway can be defined as

$$\text{Headway} = f(\text{Tt, Buses})$$

where Tt is travel time and Buses is the number of buses. Travel time in turn is a function of commercial speed and distance, and therefore of line mileage.

The first cost driver considered is line mileage, since many of the costs (such as fuel) are directly related to it. Nevertheless, other possible cost generators emerge during the analysis, as summarised in Table 5. Only relevant activities for this cost object (headway) appear.

Mileage emerges only in one of the activities considered, even though it can be argued that other generators such as driving hours are correlated with mileage. Nevertheless, most of the

Activities	Cost generator
Staff operation (driving)	Driving hours
Non-driving operation staff	Mileage
Vehicle cleaning	Number of buses
Programmed maintenance	Number of workshop hours
Non-programmed maintenance	Number of workshop hours
Vehicle management	Number of buses
Staff management	Number of drivers

Table 5. Cost generators associated with activities

direct costs and activities are related to mileage in one way or another. Fuel is a somewhat different case as it is not an activity but rather a raw material, and therefore it is directly assigned to the object cost based on mileage.

5.5 Application of the ABC method and results

Table 6 shows the initial activity consideration according to the discussion and selection made with the cost decoupling for each activity. Cost generators' names are indicated as well as the total value for performance indicators, and primary cost generator rates.

The next step according to this application of the ABC methodology assigns indirect costs (in this case vehicle management and staff management) to primary activities. For the case study, the total costs of secondary activities were assigned to primary activities proportionally to their participation in the cost structure. That led to the results in Table 7 in which a secondary rate was obtained.

Once the cost generators were obtained, the last step assigned costs to objects using these drivers. The cost object in this case was a 10% improvement of headway. If the average headway for the contract was 22.6 min, a 10% improvement meant a 2.26 min less headway for the whole operation, distributed proportionally among different lines.

This improvement lead to different impacts on the variables from which headway derived, namely number of buses, mileage, driving hours and workshop hours. There was an additional calculated number of buses (four) and a subsequent increment in mileage and driving hours (considering that commercial speed remained unchanged). Workshop hours were more dependent on the number of buses. After application of cost drivers to each activity linked to headway, the results of the marginal costs are as shown in Table 8.

Therefore a cost of €757 353 corresponds to an overall 10% improvement in headways. That represents a 7% of the total costs of the contract.

Activity	Total activity costs: €	Cost generator	Total measure of cost driver	Primary rate: €/unit
Staff operation (driving)	3 367 772	Driving hours	137 169	24.55
Non-driving operation staff and other operational resources	1 637 296	Mileage: km	3 282 283	0.4988283
Vehicle cleaning	131 339	Number of buses	39	3367.67
Programmed maintenance	526 185	Number of workshop hours	8748	60.15
Non-programmed maintenance	156 432	Number of workshop hours	8748	17.88
Vehicle management	1 379 269	Number of buses	39	35 365.86
Staff management	204 245	Number of drivers	74.87	2727.99

Table 6. Activity costs, total generator values and primary rates

Activity	Total activity costs: €	Cost generator	Total measure of cost driver	Secondary rate: €/unit
Staff operation (driving)	4 284 234	Driving hours	137 169	31.23
Non-driving operation staff and other operational resources	2 082 848	Mileage: km	3 282 283	0.6345729
Vehicle cleaning	167 080	Number of buses	39	4284.11
Programmed maintenance	143 189	Number of workshop hours	8748	16.37
Non-programmed maintenance	42 569	Number of workshop hours	8748	4.87

Table 7. Activity costs, total generator values and secondary rates

Activity	Costs of 10% frequency rise: €
Staff operation (driving)	442 868
Non-driving operation staff and other operational resources	208 285
Vehicle cleaning	17 136
Programmed maintenance	68 654
Non-programmed maintenance	20 410
Total	757 353

Table 8. Costs resulting from a 10% improvement in headway following ABC application

Under a more traditional approach, a direct application of the total unit mileage cost would have been applied to a 10% increase of mileage, which would have led to a total cost of €1.08 million, 43% higher than the results obtained by the ABC methodology.

6. Conclusions and further research

Existing academic literature on quality in public transport focuses mainly on the user's point of view, without a practical

application for quality costing. Although theoretical approaches are complex and detailed, they are not useful to assess the real economic impact of quality for operators and administrations. Furthermore, there are not many examples in scientific literature of the application of ABC method in public transport operations and specifically in the costing of quality variables. The results of this research show that the ABC method can be fully applied for quality costing in public transport, with more accurate results than the usual approach based on traditional accounting and mileage costing. The application of the method, however, requires a complex and deep analysis of the processes and organisation of the company. In the case study, the calculation of costs linked to an improvement of a quality variable such as line headway has shown a valuation of around 40% less than the more straightforward and simpler (and more usual) method of mileage costs.

Nevertheless the application of ABC methodology in the case study has highlighted some areas that require improvement and further research, such as the following.

- It would be preferable to divide groups of lines according to their function (in the case study, urban against metropolitan), or even to analyse each line separately and

the improvements in frequency for each individual line. In the case study, this information was not available.

- Overhead analysis within the centre cost of the case study can be improved, requiring deeper analysis of the structure and organisation of the company costing procedures and assignments, therefore affecting overhead assignment.

Interviews are a key element in the ABC analysis and it is highly recommended to conduct them in any application of the ABC method. Preparation, management and analysis of these interviews are paramount to obtain a clear and accurate process mapping of company activities.

The determination of costs linked to quality attributes through this objective method, offers other advantages for further research and application. Penalties (or incentives) within a contract linked to quality measures can be referred to these costs, as well as the improvement of a most efficient Customer Satisfaction Index (CSI), putting more resources on those variables with less cost and most impact on customer perception. An objective function could be determined taking into account the combination of attributes, weights, costs and improvement margins, so that the maximum values of this function determine the most efficient resource allocation.

This method is also a powerful tool to monitor and foster the upgrade of productivity of personnel and equipment, and in general to every element of the processes and activities in the company. Furthermore the consideration of actual quality costing, offers an opportunity to operators, administrations and funding bodies to provide better quality with a better distribution of resources. This is particularly important in poverty environments where efficiency is paramount.

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